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PALEOZOIC DIASTROPHICS OF THE NORTHERN MEXICAN TABLELAND

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A little below the southern boundary of Colorado the Rocky Mountains, in a triple cluster of canoe-shaped folds, plunge steeply beneath the general plains surface of the northern prolongation of the Mexican tableland, never again to reappear. In marked contrast to the prevailing relief expression of the Cordillera, with its stream-cut profiles, the physiognomy beyond is that of typically enisled landscape of the desert, fashioned mainly by the winds. The chain aspect of the Rockies gives way to solitary ridges. All mountains assume the character of short, lofty ranges which, with startling abruptness, rear themselves like volcanic isles jutting from a summer sea. So thickly do these isolated piles stud the vast smooth plateau plains that Dutton aptly likens them on the map to an army of caterpillars crawling northward out of Old Mexico.

Inasmuch as the northern extension of the Mexican tableland is included mainly within the present limits of the state of New Mexico its topographical features, so far as the United States go, are in many respects quite unique. Throughout this region the areal distribution of the geological formations is probably the least understood of any considerable tract in our country. In only a few circumscribed districts is the geological structure brought out properly and correctly in mapping. Elsewhere, according to published information, the region seems to be a veritable *terra incognita*. Even the larger relationships of the formations are so little known that they have yet to be exactly determined.

Over this northern segment of the lofty tableland the general plains surface lies evenly about a mile above the sea. Towering still another mile in the air are the innumerable mountain masses. The intermontane plains being chiefly desert or semi-arid, rock outcrops are few in number; and drifting sands and mobile earths prevail. Over such a country geological boundaries are not easily traced; and determination of the original areal distribution of the various terranes is beset with exceptional difficulties.

In most other parts of the world the local stratigraphic succession and general mapping of rock tracts are based chiefly on the rock exposures bordering the valleys of incised streams. These outcrops as a rule lie below the general upland level of the country. In the New Mexican field, the rock sections lie principally above the general plains surface. Correlative determinations of outcrops are thus exactly the reverse of what they usually are.

Disposition of the sections, a mile or more high in many instances, is that of a myriad of drill-cores set upon a board. Spaces between sections are voids in nature as in model. Under ordinary circumstances these intersectional intervals are filled up by the rock masses of the interstream areas. In order properly to visualize the geological formations of the tableland the various sections have to be connected and projected on a common plane. Such a ground plan is very different from a normal geological map. Yet it is the only kind of a diagram that satisfactorily depicts the larger relationships of the geological formations. For the region under consideration such a projection is represented in the accompanying cut (Fig. 1), the base plane selected being the ancient peneplain lying at the base of the great Pennsylvanian limestone plate.

The fact that at the southern extremity of the Rockies the Pennsylvanian limestones everywhere rest directly on pre-Cambrian schists long led to the inference that a region of continental proportions had been a land area during the greater part of Paleozoic times. Such apparently was not the case. When, a decade ago,[1] the geological formations of New Mexico were briefly described in a systematic way, a circumstance that was expressly pointed out was that while over all the northern half of the state there were no Paleozoics below the Pennsylvanian limestones, it did not preclude the existence of some, or even all, of the early periodic sections elsewhere. In fact, in southern New Mexico isolated sections of these

[1] *Report of Governor of New Mexico to Secretary of Interior for 1903*, pp. 337–41, 1904.

older rocks were incidentally noted very early. These outcrops were so widely disconnected as to give rise in some quarters to not a little doubt concerning the actual presence of some of the terranes.

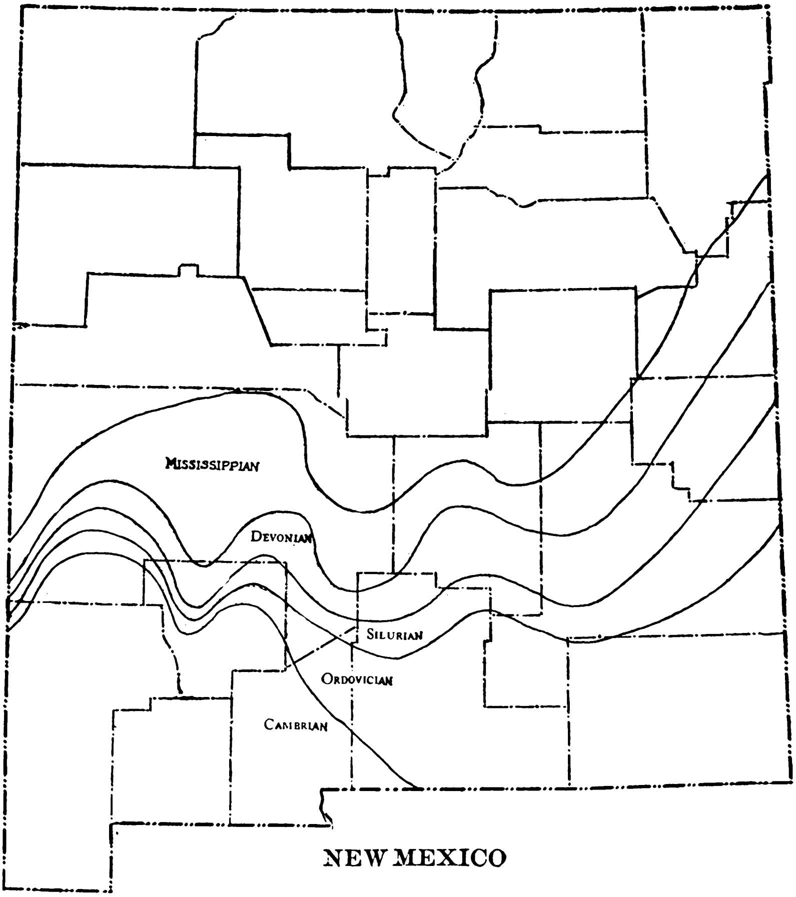

FIG. 1.—Areal distribution of Paleozoic periodic formations

Pioneer observations now seem to be fully verified. As early as 1874 Dr. W. P. Jenney[1] called attention to the presence of Cambrian rocks in the Franklin Range north of El Paso. In the same locality Dr. A. Wislizenus,[2] thirty years before, collected characteristic Ordovician fossils. Numerous organic remains of Silurian age were obtained at Santa Rita, in 1873, by Professor G. K. Gilbert.[1] Devonian strata were first recorded in New Mexico by Thomas Antisell;[2] and in the following year the fossils were described from this region by Professor James Hall.[3] Mississippian forms collected by Professor E. D. Cope were described in 1881 by Mr. S. A. Miller.[4] The most northerly points at which they were recognized recently were in the Magdalena Mountains, west of Socorro,[5] and in the Sierra Ladrones 25 miles north.

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[1] *Proc. New York Lyc. Nat. Hist.*, Vol. II (1874), p. 69.

[2] *Memoir of Tour through Northern Mexico in 1846–47* (1848), 141 pages.

So in New Mexico prior to the year 1880 all of the periodic terranes of Paleozoic age had been already fully identified.

In this tableland region the outstanding feature of the stratigraphy, and a characteristic which is perhaps nowhere else met with, is a notable segregation, instead of the usual alternation, of the hard and soft strata. Resistant beds are confined chiefly to the bottom half of the vertical section; and nearly all of the weak rocks occur only in the upper part. For a succession more than 10,000 feet in thickness this circumstance is certainly a quite remarkable one. Almost the entire Paleozoic sequence is thus composed of limestones of such uniform lithologic texture and aspect that it is not usually possible by casual glance to detect the parts of different geologic age. Only by careful discrimination of the successive faunas at the various stratigraphic levels are even the larger, or periodic, subdivisions rendered determinable. Yet, on the whole, the sequence is one of the most complete on the American continent. Out of twenty-five major terranes holding serial rank only five seem to be missing.

Both by reason of its completeness and because of its peculiar continental relationships this general geological section of the New Mexican Paleozoics is for purposes of reference one of the important successions of the country. As determined by various parties from the United States Geological Survey, and the State Geological Survey, and by others who have worked more or less extensively in the region, the essential features of the section are well epitomized in recently published tables.[1]

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[1] *U.S. Geog. and Geol. Surv. W. 100th Merid.*, Vol. III (1875), p. 117.

[2] *Explo. and Surv. Pacific Railroad*, Vol. III (1856), Pt. II, p. 181.

[3] *United States and Mexican Bound. Surv.*, Vol. I (1857), Pt. II, p. 104.

[4] *Jour. Cincinnati Soc. Nat. Hist.*, Vol. IV (1881), p. 314.

[5] *Proc. Iowa Acad. Sci.*, Vol. XII (1905), p. 169.

Since it is with marked unconformity that the Paleozoics rest upon the pre-Cambrian crystallines it is evident that long before Paleozoic deposition in the region set in, the old continental complex was beveled off to a smooth plain. This ancient erosion surface cuts evenly the folded, faulted, and altered pre-Cambrian strata, the more or less highly metamorphosed clastics, and the strictly igneous masses and intrusions. It doubtless represents as true a peneplain as ever existed, and one that remained longer and nearer base level than any other one known in geological history. The presence of this once low-lying plain and the near-shore deposition of the vast piles of homogeneous limestones appear strongly to support the idea of the existence of a close genetic relationship between the two phenomena.

Notwithstanding the fact that such exceptional homogeneity prevailed throughout the Paleozoic succession of the northern Mexican tableland, no less than a dozen major unconformities attest the frequency and extent of notable diastrophic movement. Of these by far the most conspicuous hiatus is that at the base of the Pennsylvanian limestones. In every way it is the most pretentious. Its character and position associate it with the similar phenomenon displayed in the Mississippi Valley. From that it differs in the apparent absence of the Coal Measures. However, this dissimilarity fades since remnants of the latter are now known to be actually present. How extensive they originally were is yet a matter of conjecture.

In the Ladronesian series, exposed in a circumscribed basin near Socorro,[2] are represented the all but vanquished coal shales which may be the southwestern extension of the great Arkansan series of the Ozark region. The unconformity plane is comparable in every way with that found at the base of the Coal Measures of Iowa, Missouri, and Illinois. It extends far to the north in Colorado; and far to the south in Old Mexico. Although in the Rocky

[1] *Proc. Iowa Acad. Sci.*, Vol. XXII (1916), pp. 249–71.

[2] *Journal of Geology*, Vol. XII (1904), pp. 250–51.

Mountains region all strata down to the pre-Cambrian complex are removed and the Pennsylvanian limestones rest directly upon the ancient crystallines, in southern New Mexico the same limestone plate reposes on the beveled edges of all of the older and somewhat deformed Paleozoics (Fig. 2).

Certain peculiarities in the areal distribution of the Paleozoic formations in southern and central New Mexico at once raise far-reaching questions in diastrophics. Among them not the least significant is whether the northern limits of the several major terranes are approximately the original boundaries of deposition, or whether these periodic terranes once extended indefinitely northward over the tract which later was upraised into the Rocky Mountain arch.

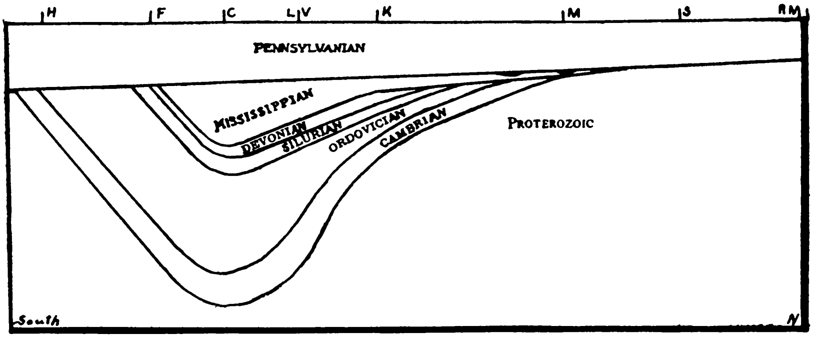

FIG. 2.—Relations of periodic formations south of Rocky Mountains

Casual consideration of present conditions points sometimes to one conclusion and sometimes to the other. Critical evidence centers on the character of the marked unconformity at the base of the Pennsylvanian section. The present northern boundaries of the other periodic terranes are very close together (Fig. 1). The strata are all virtually limestones. There are practically no characteristic shore deposits represented. Positions of none of the formations indicate that there are any well-defined overlaps. All features considered, the conclusion appears inevitable that the strand oscillations at different times were of great magnitude, amounting to hundreds of miles, instead of very short distances as at first glance seems probable.

Paleogeographical maps commonly show the southern Rocky Mountain region as a huge island persisting throughout Paleozoic times. Orographic arching of the tract appears to have taken place only late in the era. For the first time since pre-Cambrian days general peneplanation does not appear until the Mississippian or Pennsylvanian period.

That the peneplanation at the beginning of Pennsylvanian times, when Coal Measures were being deposited elsewhere around the growing American continent, was extensive is strongly supported by many facts. Since farther north in the Rocky Mountains area the older Paleozoics are present in a few limited and isolated belts, where they are preserved through infolding with more ancient rocks, it is presumed that Cambrian, Ordovician, Silurian, Devonian, and Mississippian strata as they are represented in the South doubtless once extended entirely over the province before its epeirogenic uprising. Over the Mexican tableland district last lingering traces of the old formations remained until the grand erosional period represented elsewhere to the eastward by the Arkansan (Pennsylvanian) deposition. It may be that the Pennsylvanian peneplanation epoch of the southwestern region is to be exactly paralleled with that of Iowa where it is designated as the Arkansan hiatus.

Another reason why in the Cordilleran region north of the Mexican tableland the Paleozoics do not appear more frequently than they do is that Triassic peneplanation was also profound. This surface is largely covered by mid-Cretaceous sediments before the eastern front of the Rockies is reached. Along this border the more ancient rocks are thus not open to inspection.

The rather abrupt termination of the several periodic terranes of the Paleozoic toward the north in central New Mexico does not appear to be altogether a direct result of successive advances of the ancient sea in that direction over a low-lying even coast. If any part of the abrupt thinning is thus to be ascribed it is entirely lost through repeated and profound planation effects. After the laying down of the great Pennsylvanian limestones no less than two of these planation periods are clearly indicated by marked unconformities displayed in the general stratigraphic succession of the region. When the great peneplanation of Jurassic or early Cretaceous times took place, as marked by the basal surface of the extraordinarily widespread Dakotan sandstones, it was accompanied by extensive and diverse deformation with some display of volcanic action. So extensive was this main evening that so far south as central New Mexico the Dakotan sandstone is seen to repose upon the upturned and locally vertical edges of the Pennsylvanian limestones. A most notable section demonstrating these relationships is well displayed on the Chupadera Mesa, at Dios Springs, and in the Arroyo Chupadera, about thirty miles northeast of Socorro (Fig. 3).

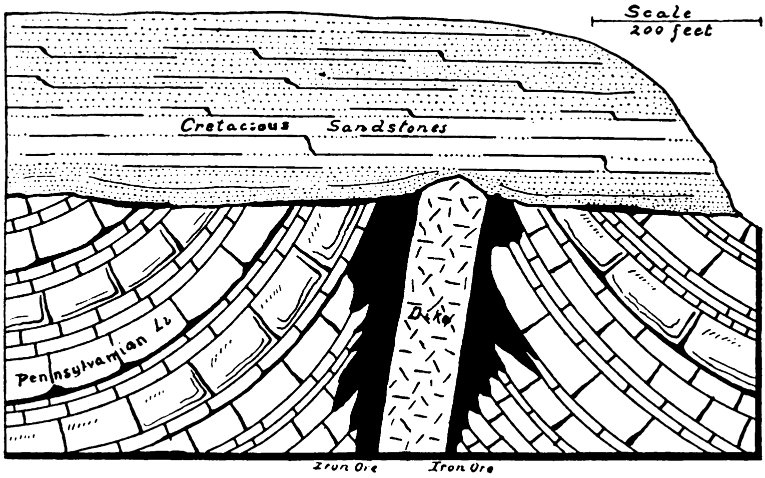

FIG. 3.—Unconformable relations of Cretaceous and Pennsylvanian beds on Chupadera Mesa, New Mexico.

The fancied complexity of the stratigraphy of the Mexican tableland is therefore more apparent than real. Two features in particular tend to obscure the actual mass relationships of the formations. Of these the wide separation of exposed rock sections assumes an importance out of all proportion to its difficulties or its merits. The phenomena attending diastrophic movements in the region are thus liable to serious misinterpretation. Neither the moderate flexing nor the profound faulting are found to be so recent as to retain their impress in full force upon the present relief. These major crustal movements are mainly quite remote. Beginning at the close of Paleozoic time they continue without interruption until the present day. The effects which their supposed dominancy produces in the existing desert ranges are now known to be due entirely to other causes. On the whole the desert ranges seem to owe their physiognomy to vigorous wind erosion under the stimulus of aridity rather than to recent deformation. Under these abnormal conditions old structures are brought out into strong relief by simple differential erosion of weak and resistant rock belts. This desert degradation so vigorous at the present day may have been of long duration, having gone on since the beginning of Tertiary times.

The post-Cretaceous wrinkling of the Rocky Mountains is reflected in the areal distribution of the rock-formations far beyond the southern terminus of that cordillera, reaching many miles into the Mexican tableland.